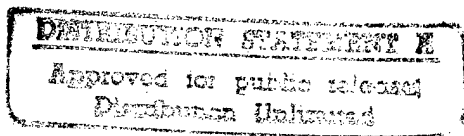


FINAL REPORT  
APRIL 1997

REPORT NO. 96-62

MODULAR ARTILLERY CHARGE  
SYSTEM (MACS) PA161E1  
CONTAINER REDESIGNED PALLET  
MIL-STD-1660 TESTS



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Prepared for:  
U.S. Army Armament Research, Development  
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VALIDATION ENGINEERING DIVISION  
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REPORT NO. 96-62

MODULAR ARTILLERY CHARGE SYSTEM (MACS) PA161E1 CONTAINER  
REDESIGNED PALLET MIL-STD-1660 TESTS

TABLE OF CONTENTS

PART	PAGE NO.
1. INTRODUCTION.....	1-1
A. BACKGROUND .....	1-1
B. AUTHORITY .....	1-1
C. OBJECTIVE .....	1-1
D. CONCLUSION.....	1-1
E. RECOMMENDATION .....	1-1
2. ATTENDEES.....	2-1
3. TEST PROCEDURES .....	3-1
4. TEST EQUIPMENT .....	4-1
5. TEST RESULTS .....	5-1
6. PHOTOGRAPHS.....	6-1

## PART 1

### INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct MIL-STD-1660 tests on a Modular Artillery Charge System (MACS) PA161E1 container redesigned pallet.

B. AUTHORITY. This test was conducted IAW mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, Illinois.

C. OBJECTIVE. The objective of these tests was to ascertain that the MACS PA161E1 container redesigned pallet met MIL-STD-1660 requirements.

D. CONCLUSION. The welds on the posts under the deck and the metal skid failed. The failure of the welds under the deck caused the exterior and middle posts on the outside skids to shear vertically through the deck of the pallet. Also, the top and bottom adapters bowed permanently; therefore, the MACS PA161E1 container redesigned pallet did not meet MIL-STD-1660 requirements.

E. RECOMMENDATION. Following pallet redesign, further testing is recommended.

PART 2

19 - 20 SEPTEMBER 1996

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## PART 3

### TEST PROCEDURES

The test procedures outlined in this section were extracted from MIL-STD-1660, Design Criteria for Ammunition Unit Loads, 8 April 1977. This standard identifies nine steps that a unitized load must undergo if it is to be considered acceptable. The four tests that were conducted on the test pallets are summarized below.

A. STACKING TEST. The unit load was loaded to simulate a stack of identical unit loads stacked 16 feet high, for a period of one hour. This stacking load was simulated by subjecting the unit load to a compression weight equal to an equivalent 16-foot stacking height. The compression load was calculated in the following manner. The unit load weight was divided by the unit load height in inches and multiplied by 192. The resulting number was the equivalent compressive force of a 16-foot-high load.

B. REPETITIVE SHOCK TEST. The repetitive shock test was conducted IAW Method 5019, Federal Standard 101. The test procedure is as follows: The test specimen was placed on, but not fastened to, the platform. With the specimen in one position, the platform was vibrated at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3 cycles per second. The frequency was steadily increased until the package left the platform. The resonant frequency was achieved when a 1/16-inch-thick feeler gage momentarily slid freely between every point on the specimen in contact with the platform at some instance during the cycle or a platform acceleration achieved  $1 \pm 0.1$  Gs. Midway into the testing period, the specimen was rotated 90 degrees and the test continued for the duration. Unless failure occurred, the total time of vibration was two hours if the specimen was tested in one position and three hours for more than one position.

C. EDGEWISE ROTATIONAL DROP TEST. This test was conducted using the procedures of Method 5008, Federal Standard 101. The procedure for the edgewise rotational drop test is as follows: The specimen was placed on its skids with one end of the pallet supported on a beam 4-1/2 inches high. The height of the beam was increased if necessary to ensure that there was no support for the skids between the ends of the pallet when dropping took place, but was not high enough to cause the pallet to slide on the supports when the dropped end was raised for the drops. The unsupported end of the pallet was then raised and allowed to fall freely to the concrete, pavement, or similar underlying surface from a prescribed height. Unless otherwise specified, the height of drop for level A protection conforms to the following tabulation:

GROSS WEIGHT (WITHIN RANGE LIMITS) (Pounds)	DIMENSIONS OF ANY EDGE, HEIGHT OR WIDTH (WITHIN RANGE LIMITS) (Inches)	HEIGHT OF DROPS ON EDGES	
		Level A (Inches)	Level B (Inches)
150 - 250	60 - 66	36	27
250 - 400	66 - 72	32	24
400 - 600	72 - 80	28	21
600 - 1000	80 - 95	24	18
1000 - 1500	95 - 114	20	16
1500 - 2000	114 - 144	17	14
2000 - 3000	Above 145 - No limit	15	12
Above - 3000		12	9

D. INCLINE-IMPACT TEST. This test was conducted by using the procedure of Method 5023, Incline-Impact Test of Federal Standard 101. The procedure for the incline-impact test is as follows: The specimen was placed on the carriage with the surface or edge which is to be



impacted projecting at least 2 inches beyond the front end of the carriage. The carriage was brought to a predetermined position on the incline and released. If it is desired to concentrate the impact on any particular position on the container, a 4- by 4-inch timber was attached to the bumper in the desired position before the test. No part of the timber was struck by the carriage. The position of the container on the carriage and the sequence in which surfaces and edges are subjected to impacts was at the option of the testing activity and depends upon the objective of the tests. This test is to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen was subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the velocity at time of impact was 7 feet per second.

## PART 4

### TEST EQUIPMENT

#### A. Redesigned Pallet (Test Sample).

- |            |              |
|------------|--------------|
| 1. Height: | 52 inches    |
| 2. Width:  | 31.5 inches  |
| 3. Length: | 46.5 inches  |
| 4. Weight: | 2,500 pounds |

#### B. Compression Tester.

- |                       |                      |
|-----------------------|----------------------|
| 1. Manufacturer:      | Ormond Manufacturing |
| 2. Platform:          | 60- by 60-inches     |
| 3. Compression Limit: | 50,000 pounds        |
| 4. Tension Limit:     | 50,000 pounds        |

#### C. Transportation Simulator.

- |                  |                    |
|------------------|--------------------|
| 1. Manufacturer: | Gaynes Laboratory  |
| 2. Capacity:     | 6,000-pound pallet |
| 3. Displacement: | 1/2-inch amplitude |
| 4. Speed:        | 50 to 400 rpm      |
| 5. Platform:     | 5- by 8-foot       |

#### D. Inclined Plane.

- |                  |                    |
|------------------|--------------------|
| 1. Manufacturer: | Conbur Incline     |
| 2. Type:         | Impact Tester      |
| 3. Grade:        | 10 percent incline |
| 4. Length:       | 12-foot            |

## PART 5

### TEST RESULTS

TEST OBSERVATION: The test pallet was loaded with 36 PA161E1 containers. Each container was filled to approximately 63.5 pounds, creating a 2,500-pound unitized load. During the edgewise rotational drop test, excessive bowing of the top and bottom adapters occurred. The posts at the exterior and middle portions of the pallet sheared in a vertical direction as the welds on the center and outside posts of the outside skid cracked, while the bottom portion of the pallet bent.

A. STACKING TEST. The test sample was initially loaded to 9,420 pounds compression. The compression was released after a period of one hour. No measurable deformation was noticed on the test pallet.

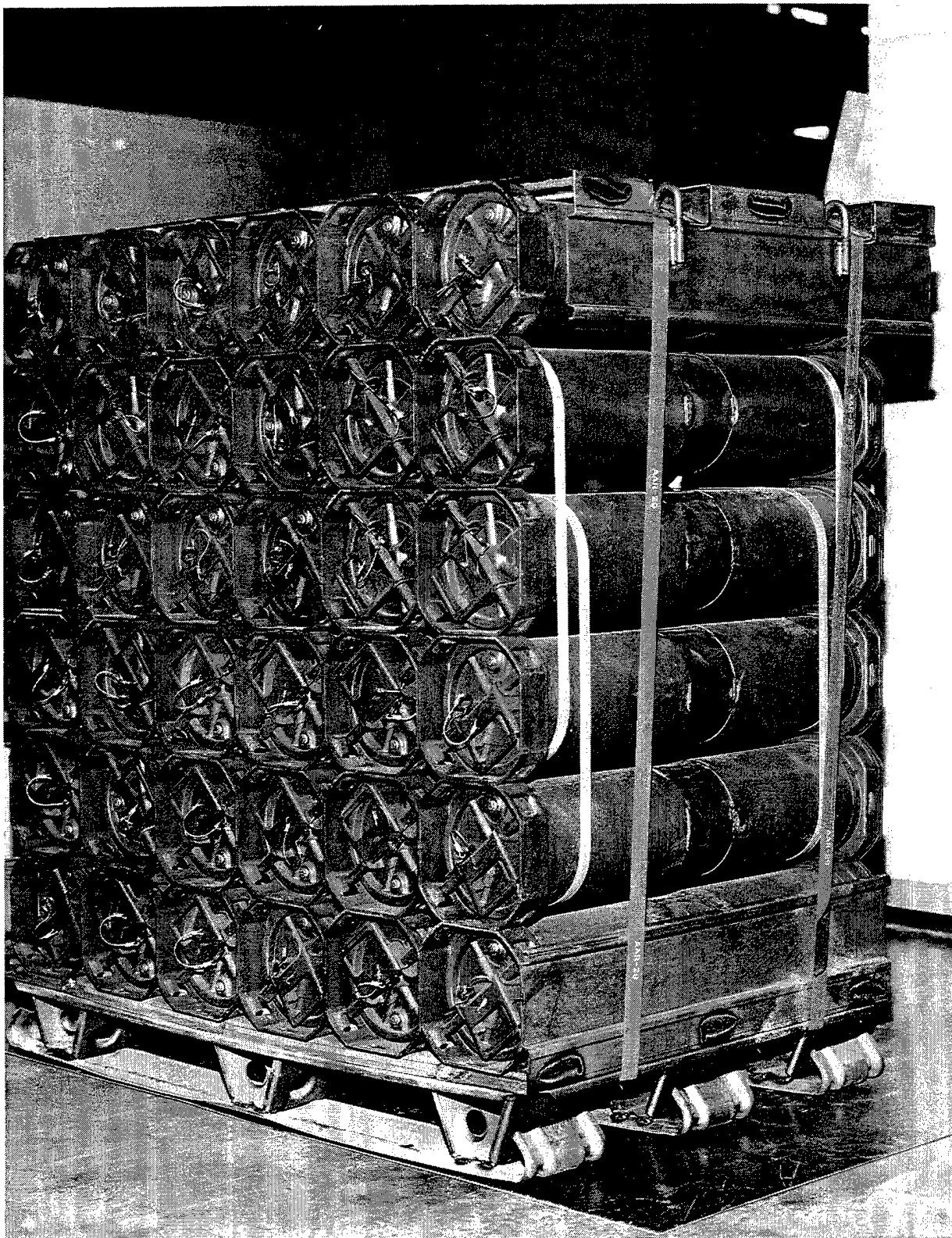
B. REPETITIVE SHOCK TEST. The redesigned pallet successfully passed the longitudinal transportation test in a 90-minute period. The operational speed for this orientation was 165 rpm. Rotating the pallet 90 degrees in a lateral orientation and subjecting it to a second 90-minute period in the transportation simulator caused no physical damage to pallet or the adapter. The operational speed at this orientation was 175 rpm. The approximate driving force into the load from the transportation simulator was 0.5 G acceleration. No physical damage was noticed at the end of this test.

C. EDGEWISE ROTATIONAL DROP TEST. Each side of the pallet was placed on a beam displacing it 4-1/2 inches above the floor. The opposite end of the pallet was raised to a height of 15 inches, then dropped. This process was repeated in a clockwise direction until all four sides of the pallet had been tested. At the completion of the test, the bowing of the top and bottom adapters was noticed as well as the broken posts and cracked welds.

D. END OF TEST INSPECTION. The outside skid that was still attached to the pallet appeared to be slightly damaged.

PART 6

PHOTOGRAPHS

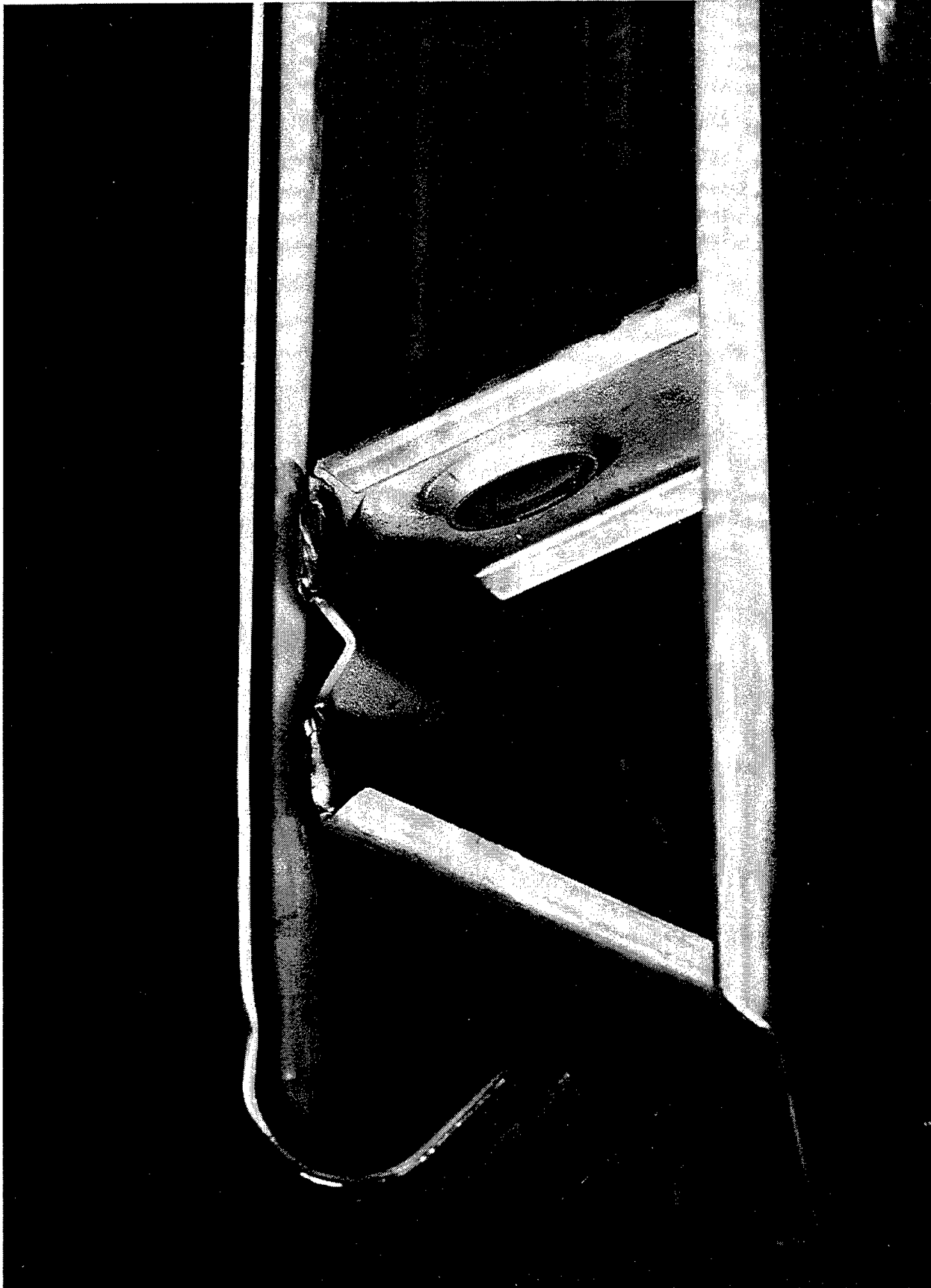


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A0317-SCN-96-173-4412. This photo shows the configuration of the palletized unit load.

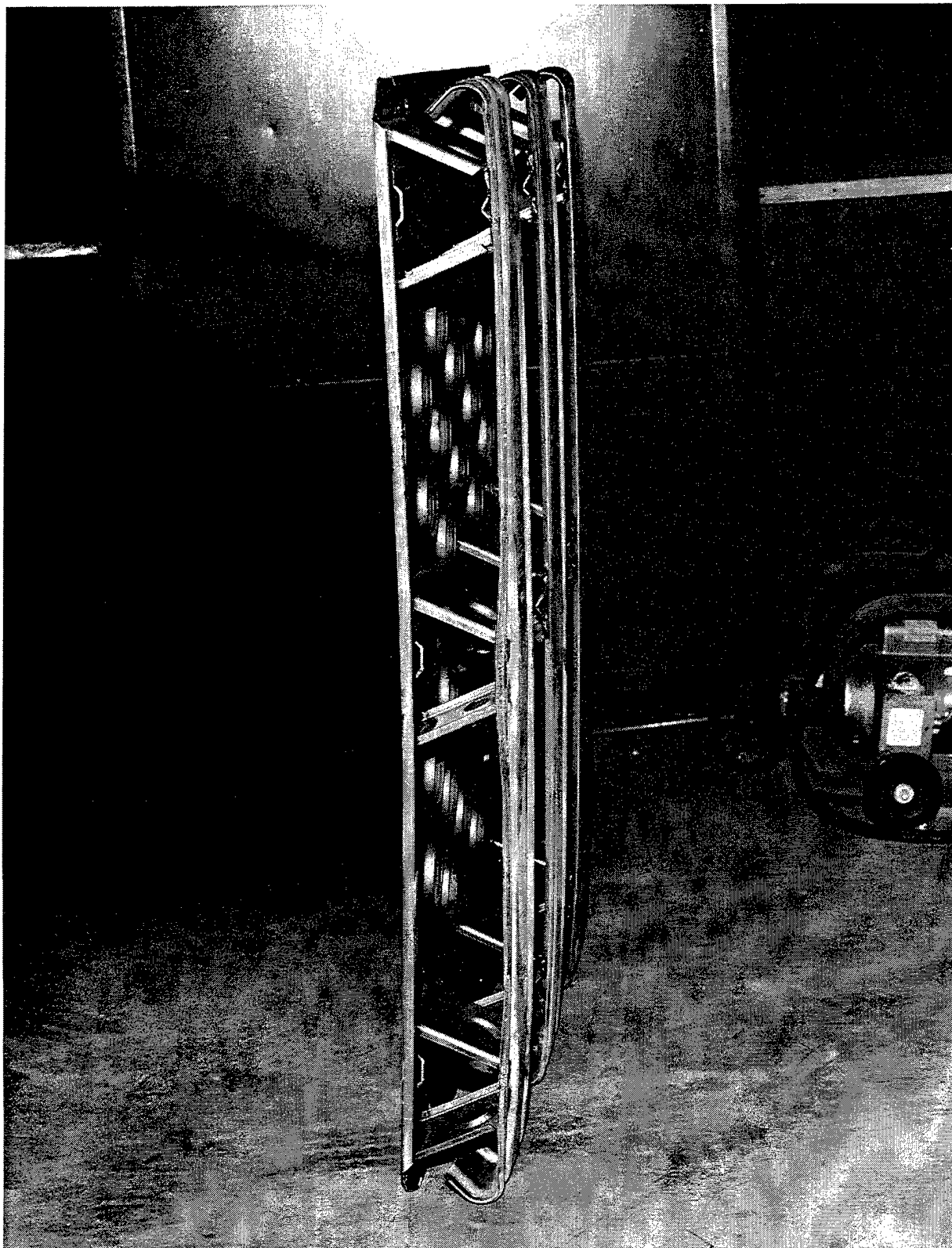


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A0317-SCN-96-173-4411. This photo shows the sheared section of the outside post.		



	U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL	
A0317-SCN-96-173-4448. This photo shows the cracked section of the welds.		





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A0317-SCN-96-173-4451. This photo shows the bowed section on the bottom of the pallet.